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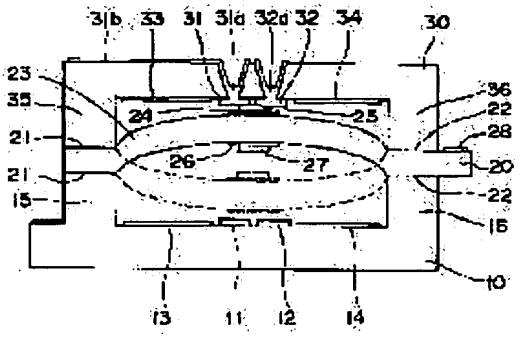
(54) MICRO RELAY

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a microminiaturized microrelay, having less resistance when a contact is turned on, and excellent vibration resistance, a frequency characteristic, and an insulating property, while concurrently ensuring desired contact pressure and a distance between contacts.
SOLUTION: Movable contacts 25 and 27 are provided respectively on the center part of the front and rear surface of a movable part 23, composed of the thin platelike base material of single crystal silicon and fixedly supporting at both the end parts so as to be bent to one side. While a pair of fixed contacts 31, 32, and 11, 12, connectably/disconnectably facing the movable contacts 25 and 27, are formed respectively on the opposite surfaces of the fixed base plates 30 and 10 facing the movable part 23, and also drive electrodes 33, 34, and 13, 14 are provided respectively on the peripheral vicinity of the fixed contacts 31, 32, and 11, 12.



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CLAIMS

[Claim(s)]

[Claim 1] The micro relay characterized by establishing a driving means near the perimeter of said stationary contact while, preparing a traveling contact in an one side center section at least so that it may consist of a sheet metal-like base material of a single crystal and may curve to one side and forming the stationary contact of the couple which counters this traveling contact possible [attachment and detachment] in the opposed face of the fixed substrate which counters said moving part. [the rear face of a table of the moving part which did fixed support of the both ends at least]

[Claim 2] The micro relay according to claim 1 characterized by said moving part being the diaphram configuration which carried out fixed support of the perimeter edge.

[Claim 3] The micro relay according to claim 1 or 2 characterized by said driving means being the actuation electrode which attracts said moving part with electrostatic attraction.

[Claim 4] A micro relay given in claim 1 characterized by having arranged the fixed substrate so that it may counter at intervals of predetermined to the table rear face of said moving part thru/or any 1 term of 3.

[Claim 5] A micro relay given in claim 1 characterized by said fixed substrate being glass material or single-crystal-silicon material thru/or any 1 term of 4.

[Claim 6] A micro relay given in claim 1 characterized by forming in the table rear face of said moving part an energization means to increase the energization force of the thickness direction thru/or any 1 term of 5.

[Claim 7] The micro relay according to claim 6 characterized by said energization means being the thermal oxidation film.

[Claim 8] A micro relay given in claim 1 characterized by establishing the auxiliary driving means which decreases the energization force of the moving part which curved at least on one side at the time of actuation while on the rear face of a table of said moving part thru/or any 1 term of 7.

[Claim 9] The micro relay according to claim 8 said whose auxiliary driving means is characterized by being a piezo-electric thin film.

[Claim 10] The micro relay according to claim 8 characterized by said auxiliary driving means being the ctenidium-like electrode of a couple which is formed in the medium end face of a movable substrate, and gets into gear in the state of non-contact.

[Claim 11] A micro relay given in claim 1 thru/or 10 any 1 terms characterized by

stationing said moving part in the decompressed seal space.

[Claim 12] A micro relay given in claim 1 characterized by being filled up with an insulator layer generating prevention gas in the seal space which has stationed said moving part thru/or any 1 term of 11.

[Claim 13] A micro relay given in claim 1 characterized by being contained by the stowage container through an impact absorber thru/or any 1 term of 12.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to a micro relay and the self-hold mold micro relay which can maintain the bow condition of moving part especially.

[0002]

[Description of the Prior Art] Conventionally, as a relay, there is an electromagnetic relay using an electromagnet, for example. However, since a mechanical component part is needed, while a miniaturization is difficult, since the inertia force of moving parts is large among mechanical component parts, it is easy to produce fatigue breaking and lacking in endurance. It is not easy to secure desired contact pressure and the distance between contacts simultaneously with the miniaturization in a small relay especially.

[0003] Moreover, although there are some which consist of a solid-state-switching component as a kind of a small relay, while resistance in case a contact turns on is strong and frequency characteristics are low, there is a trouble that the insulation between I/O and between like-pole terminals is low.

[0004] The resistance of this invention in case a contact turns on securing desired contact pressure and the distance between contacts simultaneously in view of said trouble is small, and it aims at offering the micro micro relay excellent in vibration resistance, frequency characteristics, and insulation.

[0005]

[Means for Solving the Problem] The micro relay concerning this invention consists of a sheet metal-like base material of a single crystal in order to attain said object. The inside on the rear face of a table of the moving part which did fixed support of the both ends at least so that it might curve to one side, While preparing a traveling contact in an one side center section at least and forming the stationary contact of the couple which counters this traveling contact possible [attachment and

detachment] in the opposed face of the fixed substrate which counters said moving part, it has considered as the configuration which established the driving means near the perimeter of said stationary contact.

[0006] Said moving part may be the diaphram configuration which carried out fixed support of the perimeter edge. Moreover, said driving means may be an actuation electrode which attracts said moving part with electrostatic attraction. Furthermore, a fixed substrate may be arranged so that it may counter at intervals of predetermined to the table rear face of said moving part. And said fixed substrate may be glass material or single-crystal-silicon material.

[0007] An energization means to increase the energization force of the thickness direction may be formed in the table rear face of said moving part. As said energization means, there is thermal oxidation film, for example.

[0008] While on the rear face of a table of said moving part, the auxiliary driving means which decreases the energization force of the moving part which curved at the time of actuation may be prepared at least in one side. You may be the ctenidium-like electrode of a couple which is formed in a piezo-electric thin film or the medium end face of a movable substrate, and gets into gear in the state of non-contact as this auxiliary driving means, for example.

[0009] Said moving part may be stationed in the decompressed seal space. Moreover, it may be filled up with an insulator layer generating prevention gas in the seal space which has stationed said moving part. Furthermore, the whole this application micro relay may be contained to a stowage container through an impact absorber.

[0010]

[Embodiment of the Invention] Next, the operation gestalt concerning this invention is explained according to the accompanying drawing of drawing 1 thru/or drawing 4 . The micro relay concerning the 1st operation gestalt carries out the junction unification of the lower fixed substrate 10 and the up fixed substrate 30 from the upper and lower sides at the movable substrate 20, respectively, as shown in drawing 1 and drawing 2 .

[0011] The stationary contacts 11 and 12 of a couple are formed in the top-face center section, and said lower fixed substrate 10 is pulled out through printed circuits 11a and 12a, as it consists of glass material and is shown in drawing 2 (d). Furthermore, the actuation electrodes 13 and 14 of a couple are installed in the both sides of these stationary contacts 11 and 12 side by side. It connects by printed-circuit 14a so that it may become this potential, and these actuation electrodes 13 and 14 are pulled out by printed-circuit 13a. Moreover, as for the lower fixed substrate 10, the projected parts 15 and 16 for junction are formed in the top face. In addition, said lower fixed

substrate 10 may consist of single-crystal-silicon material. However, it is necessary to insulate stationary contacts 11 and 12, the actuation electrode 13, and 14 grades through an insulator layer in that case.

[0012] Said movable substrate 20 is formed by single-crystal-silicon material. And as shown in drawing 2 (c), between the junction field 21 arranged at the table rear face and 22 is made into moving part 23. Traveling contacts 25 and 27 are formed in the abbreviation center section on the rear face of a table of this moving part 23 through insulator layers 24 and 26, respectively. Furthermore, said moving part 23 is supported so that it may curve to either of the vertical directions. In addition, as for said movable substrate 20, the pad 28 for wire BONDINKU is formed in the end section of the front face.

[0013] Moreover, while on the rear face of a table of single-crystal-silicon material, the silicon thermal oxidation film may be formed in the table rear face of moving part 23 at least. It is for securing desired contact pressure simultaneously, securing the predetermined amount of displacement by giving moving part 23 the big compressive force of the silicon thermal oxidation film, giving the much more big energization force according to the thickness direction, and incurvating moving part 23.

[0014] As said up fixed substrate 30 consists of glass material like said lower fixed substrate 10 and is shown in drawing 2 (b), the stationary contacts 31 and 32 of the couple which counters said traveling contact 25 possible [attachment and detachment] are formed in the rear face which counters said movable substrate 20. Moreover, the actuation electrodes 33 and 34 are installed in the outside of these stationary contacts 31 and 32 side by side, respectively. Furthermore, the projected parts 35 and 36 for junction are formed in the edge located in the outside of these actuation electrodes 33 and 34.

[0015] And as shown in drawing 2 (a), said stationary contacts 31 and 32 of a couple are pulled out by the front face through through holes 31a and 32a, and are further pulled out to the surface edge through printed circuits 31b and 32b. Similarly, said actuation electrodes 33 and 34 of a couple are also pulled out by the front face through through holes 33a and 34a. And it connects by printed-circuit 34b so that the actuation electrodes 33 and 34 may serve as this potential, and it is pulled out through printed-circuit 33b.

[0016] In addition, said up fixed substrate 30 may consist of single-crystal-silicon material. However, it is necessary to insulate a stationary contact 31 and 32 grades through an insulator layer in that case. Moreover, aluminum, gold, silver, copper, platinum, etc. are mentioned as an actuation electrode material.

[0017] Next, the actuation approach of a micro relay of having the above-mentioned internal structure is explained. First, when the electrical potential difference is not impressed between the actuation electrodes 33 and 34 and moving part 23, moving part 23 is curving to the upper part side, and a traveling contact 25 contacts stationary contacts 31 and 32, and is making them flow.

[0018] And if an electrical potential difference is impressed between the actuation electrodes 13 and 14 and moving part 23, electrostatic attraction arises between the actuation electrodes 13 and 14 and moving part 23, and moving part 23 can draw near to the lower fixed substrate 10 side. For this reason, after moving part 23 is reversed and a traveling contact 25 opens from stationary contacts 31 and 32, a traveling contact 27 contacts stationary contacts 11 and 12. Then, even if it cancels impression of the above-mentioned electrical potential difference, moving part 23 maintains the condition.

[0019] Subsequently, if an electrical potential difference is impressed between the actuation electrodes 33 and 34 and moving part 23, after moving part 23 will be reversed and a traveling contact 27 will open from stationary contacts 11 and 12 with the electrostatic attraction produced between the actuation electrodes 33 and 34 and moving part 23, a traveling contact 25 contacts stationary contacts 31 and 32. And even if it cancels impression of an electrical potential difference, moving part 23 maintains the condition.

[0020] As shown in drawing 3 , the 2nd operation gestalt covers the table rear face of moving part 23 with the silicon thermal oxidation film (not shown) which is an insulator layer, and provides traveling contacts 25 and 27 (not shown [a traveling contact 27] in drawing 3) in the center section on the rear face of a table, respectively. And on both sides of traveling contacts 25 and 27, the piezo-electric thin films 40 and 41 are arranged as an auxiliary driving means, respectively. Furthermore, while electrical connection of the printed circuit 42 is carried out to the left side edge section of these piezo-electric thin films 40 and 41, electrical connection of the printed circuit 43 is carried out to the right side edge section of the piezo-electric thin films 40 and 41.

[0021] If an electrical potential difference is impressed to the piezo-electric thin films 40 and 41 through printed circuits 42 and 43, respectively from said external connection pads 44 and 45 for auxiliary actuation, the piezo-electric thin films 40 and 41 expand and contract in a longitudinal direction. For this reason, if impress an electrical potential difference also to said piezo-electric thin films 40 and 41, they are made to expand and contract and a part of energization force of the thickness

direction of said moving part 23 is decreased when reversing moving part 23, it can drive by driver voltage lower than the case where moving part 23 is reversed only with electrostatic attraction. Since others are the same as that of the above-mentioned 1st operation gestalt, explanation is omitted.

[0022] As the 3rd operation gestalt is shown in drawing 4 , the movable substrate 20 consists of moving part 23 and support edges 29a and 29b located in the both sides of this moving part 23, respectively. Said moving part 23 is covered with the silicon thermal oxidation film (not shown) the table rear face of whose is an insulator layer except for a part, and traveling contacts 25 and 27 (not shown [a traveling contact 27] in drawing 4) are formed in the center section on the rear face of a table. Furthermore, the ctenidium-like electrodes 50 and 51 are formed in the both-sides end face of moving part 23, respectively. On the other hand, silicon oxide is formed also in the table rear face of support edge 29a. However, while single-crystal-silicon material is exposed in the junction field 21, the external connection pad 52 is formed in the part which the single-crystal-silicon material which follows this exposes. Furthermore, the ctenidium-like electrode 53 is formed in the piece side edge side of said support edge 29a. On the other hand, silicon oxide is formed also in the table rear face of support edge 29b. However, while single-crystal-silicon material is exposed in the junction field 22, the external connection pad 54 is formed in the part which the single-crystal-silicon material which follows this exposes. Furthermore, the ctenidium-like electrode 55 is formed also in the piece side edge side of said support edge 29b.

[0023] Furthermore, the both-sides edge of moving part 23 is united with the support edges 29a and 29b through the insulating section 56. For this reason, the ctenidium-like electrodes 50 and 51 of moving part 23 get into gear in the state of non-contact, respectively to the ctenidium-like electrodes 53 and 55 of the support edges 29a and 29b, and form the auxiliary driving means. And electrical connection of the printed circuit 58 pulled out from the external connection pad 57 of support edge 29b is carried out to the single-crystal-silicon material of moving part 23 through the silicon oxide (not shown) which is an insulator layer.

[0024] According to this operation gestalt, if an electrical potential difference is impressed between moving part 23 and the support edges 29a and 29b through the external connection pads 52 and 54 and the external connection pad 57, electrostatic attraction will arise, respectively among the ctenidium-like electrodes 50 and 53 which get into gear, and among the ctenidium-like electrodes 51 and 55 which get into gear, and compressive force will be given to moving part 23. For this reason, a part of

energization force of the thickness direction of said moving part 23 which curved can decrease, and moving part 23 can be reversed by low driver voltage like the above-mentioned. Since others are the same as that of the above-mentioned 1st operation gestalt, explanation is omitted.

[0025] It is not necessary to necessarily perform closing motion of a contact by ordinary pressure, and a contact may be opened and closed in the decompressed seal space, and gases, such as an argon, nitrogen, and 6 sulfur fluorides, may be filled up with the above-mentioned operation gestalt in seal space. It is because generating of the insulator layer by the arc between contacts, joining of a contact, and degradation can be prevented.

[0026]

[Effect of the Invention] According to the micro relay concerning claim 1 of this invention, the traveling contact prepared in the center section of the curving moving part displaces greatly in the thickness direction, and attaches and detaches to the stationary contact of a couple, and it is made to flow through these so that clearly from the above explanation. For this reason, securing desired contact pressure, a desired distance between contacts can be secured simultaneously and pressure-proofing is high. Moreover, it consists of a sheet metal base material of a single crystal, and since the moving part itself is light, an inertia force is small [the moving part]. For this reason, it is hard to produce fatigue breaking and excels in endurance. Furthermore, since a traveling contact contacts the stationary contact of a couple directly and makes it flow, while frequency characteristics are high, the insulation between I/O and between like-pole terminals is high [resistance in case a contact turns on unlike a solid-state-switching component is small, and]. And the moving part where fixed support is carried out so that it may curve to one side can displace in the thickness direction through a driving means. For this reason, according to the invention in this application, the self-hold mold micro relay stabilized bidirectionally is obtained. According to claim 2, it has considered as the diaphram configuration which carried out fixed support of the perimeter edge of moving part. For this reason, it is hard to produce a twist in moving part, and per piece of a contact does not arise. Since moving part is driven with the electrostatic attraction which impresses an electrical potential difference and is produced according to claim 3, little knot electrotyping micro relay of power consumption is obtained. Since according to claim 4 the fixed substrate is provided so that it may counter at intervals of predetermined to the table rear face of moving part, the micro relay which is a seal mold, and can open and close at least 2 sets of stationary contacts by turns is

obtained. According to claim 5, a fixed substrate is glass material or single-crystal-silicon material, and since a micro-machining technique is applicable, the micro relay with high productivity is obtained. Since an energization means to increase the energization force of the thickness direction of moving part is established according to claims 6 and 7, it becomes easy to secure desired contact pressure. Since the energization force of the thickness direction of moving part in which the auxiliary driving means curved is decreased at the time of actuation according to claims 8, 9, and 10, reversal actuation of moving part becomes quick and driver voltage can be reduced. Since it is arranged in the seal space where moving part was decompressed according to claim 11, the air resistance of moving part decreases and an operating characteristic improves. According to claim 12, since it is filled up with the insulator layer generating prevention gas in seal space, it is hard coming to generate the poor insulation based on the arc between contacts, and endurance and dependability improve. According to claim 13, since an impact absorber absorbs the oscillation from the outside etc. and eases, it is effective in the micro relay which malfunction cannot produce easily being obtained.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the sectional view showing the micro relay concerning the 1st operation gestalt of the invention in this application.

[Drawing 2] The component of the micro relay shown in drawing 1 is shown, and, for drawing (a), the top view of an up fixed substrate and drawing (b) are [the top view of a movable substrate and drawing (d) of the bottom view of an up fixed substrate and drawing (c)] top views of a lower fixed substrate.

[Drawing 3] It is the top view showing the movable substrate of the micro relay concerning the 2nd operation gestalt.

[Drawing 4] It is the top view showing the movable substrate of the micro relay concerning the 3rd operation gestalt.

[Description of Notations]

10 [-- 21 A movable substrate, 22 / -- A junction field, 23 / -- 25 Moving part, 27 / -- A traveling contact, 30 / -- 31 An up fixed substrate, 32 / -- 33 A stationary contact, 34 / -- An actuation electrode, 31a 32a, 33a, 34a / -- 40 A through hole, 41

/ -- A piezo-electric thin film, 50, 51, 53, 55 / -- A ctenidium-like electrode, 56 -- Insulating section.] -- 11 A lower fixed substrate, 12 -- 13 A stationary contact, 14 -- An actuation electrode, 20

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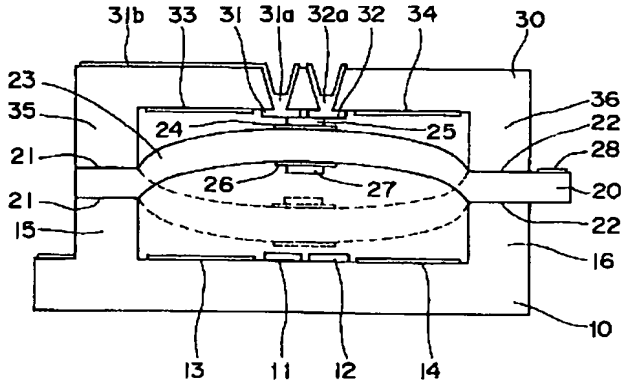
(54)【発明の名称】　マイクロリレー

(57)【要約】

【課題】　所望の接点圧と接点間距離とを同時に確保しつつ、接点がオンするときの抵抗が小さく、耐振性，周波数特性，絶縁性に優れた超小型マイクロリレーを提供することにある。

【解決手段】　単結晶シリコンの薄板状基材からなり、かつ、一方に湾曲するように両端部を固定支持した可動部２３の表裏面中央部に可動接点２５および２７をそれぞれを設ける。一方、この可動接点２５および２７に接離可能に対向する一対の固定接点３１，３２および１１，１２を、前記可動部２３に対向する固定基板３０および１０の対向面にそれぞれ形成するとともに、前記固定接点３１，３２および１１，１２の周囲近傍に駆動電極３３，３４および１３，１４をそれぞれ設ける。



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【特許請求の範囲】
【請求項１】　単結晶の薄板状基材からなり、一方に湾曲するように少なくとも両端部を固定支持した可動部の表裏面のうち、少なくとも片面中央部に可動接点を設ける一方、この可動接点に接離可能に対向する一対の固定接点を、前記可動部に対向する固定基板の対向面に形成するとともに、前記固定接点の周囲近傍に駆動手段を設けたことを特徴とするマイクロリレー。
【請求項２】　前記可動部が、その全周縁部を固定支持したダイヤフラム形状であることを特徴とする請求項１に記載のマイクロリレー。
【請求項３】　前記駆動手段が、前記可動部を静電引力で吸引する駆動電極であることを特徴とする請求項１または２に記載のマイクロリレー。
【請求項４】　前記可動部の表裏面に対して所定間隔で対向するように固定基板を配置したことを特徴とする請求項１ないし３のいずれか１項に記載のマイクロリレー。
【請求項５】　前記固定基板がガラス材あるいは単結晶シリコン材であることを特徴とする請求項１ないし４のいずれか１項に記載のマイクロリレー。
【請求項６】　前記可動部の表裏面に、厚さ方向の付勢力を増大させる付勢手段を形成したことを特徴とする請求項１ないし５のいずれか１項に記載のマイクロリレー。
【請求項７】　前記付勢手段が熱酸化膜であることを特徴とする請求項６に記載のマイクロリレー。
【請求項８】　前記可動部の表裏面のうち、少なくとも片面に、駆動時に湾曲した可動部の付勢力を減少させる補助駆動手段を設けたことを特徴とする請求項１ないし７のいずれか１項に記載のマイクロリレー。
【請求項９】　前記補助駆動手段が、圧電薄膜であることを特徴とする請求項８に記載のマイクロリレー。
【請求項１０】　前記補助駆動手段が、可動基板の中間端面に形成され、かつ、非接触状態で噛合する一対の櫛歯状電極であることを特徴とする請求項８に記載のマイクロリレー。
【請求項１１】　前記可動部が、減圧された密封空間内に配置されていることを特徴とする請求項１ないし１０いずれか１項に記載のマイクロリレー。
【請求項１２】　前記可動部を配置した密封空間内に絶縁膜発生防止気体を充填したことを特徴とする請求項１ないし１１のいずれか１項に記載のマイクロリレー。
【請求項１３】　衝撃吸収材を介して収納容器に収納されていることを特徴とする請求項１ないし１２のいずれか１項に記載のマイクロリレー。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明はマイクロリレー、特に、可動部の湾曲状態を維持できる自己保持型マイクロリレーに関する。

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【０００２】
【従来の技術と発明が解決しようとする課題】従来、リレーとしては、例えば、電磁石を利用した電磁式リレーがある。しかし、機械的構成部品を必要とするので、小型化が困難であるとともに、機械的構成部品のうち、可動部品の慣性力が大きいため、疲労破壊が生じやすく、耐久性に乏しい。特に、小型リレーにおいては、その小型化に伴い、所望の接点圧と接点間距離とを同時に確保することが容易でない。
【０００３】また、小型リレーの一種として、半導体スイッチング素子からなるものがあるが、接点がオンするときの抵抗が大きく、周波数特性が低いとともに、入出力間や同極端子間の絶縁性が低いという問題点がある。
【０００４】本発明は、前記問題点に鑑み、所望の接点圧と接点間距離とを同時に確保しつつ、接点がオンするときの抵抗が小さく、耐振性，周波数特性，絶縁性に優れた超小型のマイクロリレーを提供することを目的とする。
【０００５】
【課題を解決するための手段】本発明にかかるマイクロリレーは、前記目的を達成するため、単結晶の薄板状基材からなり、一方に湾曲するように少なくとも両端部を固定支持した可動部の表裏面のうち、少なくとも片面中央部に可動接点を設ける一方、この可動接点に接離可能に対向する一対の固定接点を、前記可動部に対向する固定基板の対向面に形成するとともに、前記固定接点の周囲近傍に駆動手段を設けた構成としてある。
【０００６】前記可動部は、その全周縁部を固定支持したダイヤフラム形状であってもよい。また、前記駆動手段は、前記可動部を静電引力で吸引する駆動電極であってもよい。さらに、前記可動部の表裏面に対して所定間隔で対向するように固定基板を配置しておいてもよい。そして、前記固定基板はガラス材あるいは単結晶シリコン材であってもよい。
【０００７】前記可動部の表裏面には、厚さ方向の付勢力を増大させる付勢手段を形成しておいてもよい。前記付勢手段としては、例えば、熱酸化膜がある。
【０００８】前記可動部の表裏面のうち、少なくとも片面に、駆動時に湾曲した可動部の付勢力を減少させる補助駆動手段を設けておいてもよい。この補助駆動手段としては、例えば、圧電薄膜、あるいは、可動基板の中間端面に形成され、かつ、非接触状態で噛合する一対の櫛歯状電極であってもよい。
【０００９】前記可動部は、減圧された密封空間内に配置されていてもよい。また、前記可動部を配置した密封空間内に絶縁膜発生防止気体を充填しておいてもよい。さらに、本願マイクロリレー全体を衝撃吸収材を介して収納容器に収納しておいてもよい。
【００１０】

【発明の実施の形態】次に、本発明にかかる実施形態を図１ないし図４の添付図面に従って説明する。第１実施形態にかかるマイクロリレーは、図１および図２に示すように、下部固定基板１０，上部固定基板３０を可動基板２０に上下からそれぞれ接合一体化したものである。

【００１１】前記下部固定基板１０はガラス材からなり、図２（ｄ）に示すように、その上面中央部に一対の固定接点１１，１２が形成され、プリント配線１１ａ，１２ａを介して引き出されている。さらに、この固定接点１１，１２の両側に一対の駆動電極１３，１４が並設されている。この駆動電極１３，１４は同電位となるようにプリント配線１４ａで接続され、プリント配線１３ａで引き出されている。また、下部固定基板１０は、その上面に接合用突部１５，１６が形成されている。なお、前記下部固定基板１０は、単結晶シリコン材からなるものであってもよい。ただし、その場合には、固定接点１１，１２、駆動電極１３，１４等を絶縁膜を介して絶縁しておく必要がある。

【００１２】前記可動基板２０は単結晶シリコン材で形成したものである。そして、図２（ｃ）に示すように、その表裏面に配置した接合領域２１，２２間を可動部２３としてある。この可動部２３の表裏面の略中央部に絶縁膜２４，２６を介して可動接点２５，２７がそれぞれ設けられている。さらに、前記可動部２３は、上下方向のいずれか一方に湾曲するように支持されている。なお、前記可動基板２０は、その表面の一端部にワイヤーボンディンク用パッド２８が設けられている。

【００１３】また、単結晶シリコン材の表裏面のうち、少なくとも可動部２３の表裏面にシリコン熱酸化膜を形成しておいてもよい。シリコン熱酸化膜の大きな圧縮力を可動部２３に付与し、厚さ方向により一層大きな付勢力を与えて可動部２３を湾曲させることにより、所定の変位量を確保しつつ、所望の接点圧を同時に確保するためである。

【００１４】前記上部固定基板３０は、前記下部固定基板１０と同様、ガラス材からなり、図２（ｂ）に示すように、前記可動基板２０に対向する裏面に、前記可動接点２５に接離可能に対向する一対の固定接点３１，３２が設けられている。また、この固定接点３１，３２の外側に駆動電極３３，３４がそれぞれ並設されている。さらに、この駆動電極３３，３４の外側に位置する端部に接合用突部３５，３６が形成されている。

【００１５】そして、図２（ａ）に示すように、一対の前記固定接点３１，３２はスルーホール３１ａ，３２ａを介して表面に引き出され、さらに、プリント配線３１ｂ，３２ｂを介して表面縁部まで引き出されている。同様に、一対の前記駆動電極３３，３４もスルーホール３３ａ，３４ａを介して表面に引き出されている。そして、駆動電極３３，３４が同電位となるようにプリント配線３４ｂで接続され、プリント配線３３ｂを介して引き出されている。

【００１６】なお、前記上部固定基板３０は、単結晶シリコン材からなるものであってもよい。ただし、その場合には、絶縁膜を介して固定接点３１，３２等を絶縁しておく必要がある。また、駆動電極材料としては、アルミニウム，金，銀，銅，プラチナ等が挙げられる。

【００１７】次に、前述の内部構造を有するマイクロリレーの駆動方法について説明する。まず、駆動電極３３，３４と可動部２３との間に電圧が印加されていない場合、可動部２３が上方側に湾曲しており、可動接点２５が固定接点３１，３２に接触し、導通させている。

【００１８】そして、駆動電極１３，１４と可動部２３との間に電圧を印加すると、駆動電極１３，１４と可動部２３との間に静電引力が生じ、可動部２３が下部固定基板１０側に引き寄せられる。このため、可動部２３が反転し、可動接点２５が固定接点３１，３２から開離した後、可動接点２７が固定接点１１，１２に当接する。その後、前述の電圧の印加を解除しても、可動部２３は、その状態を維持する。

【００１９】ついで、駆動電極３３，３４と可動部２３との間に電圧を印加すると、駆動電極３３，３４と可動部２３との間に生じる静電引力により、可動部２３が反転し、可動接点２７が固定接点１１，１２から開離した後、可動接点２５が固定接点３１，３２に当接する。そして、電圧の印加を解除しても、可動部２３は、その状態を維持する。

【００２０】第２実施形態は、図３に示すように、可動部２３の表裏面を絶縁膜であるシリコン熱酸化膜（図示せず）で被覆し、その表裏面の中央部に可動接点２５，２７（図３において可動接点２７は図示せず）をそれぞれ設けてある。そして、可動接点２５，２７の両側には圧電薄膜４０，４１を補助駆動手段としてそれぞれ配置してある。さらに、この圧電薄膜４０，４１の左側縁部にプリント配線４２が電気接続されている一方、圧電薄膜４０，４１の右側縁部にプリント配線４３が電気接続されている。

【００２１】前記補助駆動用外部接続パッド４４，４５からプリント配線４２，４３を介して圧電薄膜４０，４１に電圧をそれぞれ印加すると、圧電薄膜４０，４１が横方向に伸縮する。このため、可動部２３を反転させる場合に、前記圧電薄膜４０，４１にも電圧を印加して伸縮させ、前記可動部２３の厚さ方向の付勢力の一部を減少させれば、静電引力だけで可動部２３を反転させる場合よりも、低い駆動電圧で駆動できる。他は前述の第１実施形態と同様であるので、説明を省略する。

【００２２】第３実施形態は、図４に示すように、可動基板２０が、可動部２３と、この可動部２３の両側にそれぞれ位置する支持端部２９ａ，２９ｂとから構成されている。前記可動部２３は、一部を除き、その表裏面が絶縁膜であるシリコン熱酸化膜（図示せず）で被覆さ

れ、その表裏面の中央部に可動接点２５，２７（図４において可動接点２７は図示せず）が設けられている。さらに、可動部２３の両側端面には櫛歯状電極５０，５１がそれぞれ形成されている。一方、支持端部２９ａの表裏面にもシリコン酸化膜が形成されている。ただし、接合領域２１において単結晶シリコン材が露出しているとともに、これに連続する単結晶シリコン材が露出する部分に外部接続パッド５２が設けられている。さらに、前記支持端部２９ａの片側端面には櫛歯状電極５３が形成されている。他方、支持端部２９ｂの表裏面にもシリコン酸化膜が形成されている。ただし、接合領域２２において単結晶シリコン材が露出しているとともに、これに連続する単結晶シリコン材が露出する部分に外部接続パッド５４が設けられている。さらに、前記支持端部２９ｂの片側端面にも櫛歯状電極５５が形成されている。

【００２３】さらに、可動部２３の両側端部は絶縁部５６を介して支持端部２９ａ，２９ｂに一体化されている。このため、可動部２３の櫛歯状電極５０，５１が、支持端部２９ａ，２９ｂの櫛歯状電極５３，５５にそれぞれ非接触状態で噛合し、補助駆動手段を形成している。そして、支持端部２９ｂの外部接続パッド５７から引き出されたプリント配線５８が絶縁膜であるシリコン酸化膜（図示せず）を介して可動部２３の単結晶シリコン材に電気接続されている。

【００２４】本実施形態によれば、外部接続パッド５２，５４および外部接続パッド５７を介して可動部２３と支持端部２９ａ，２９ｂとの間に電圧を印加すると、噛合する櫛歯状電極５０，５３の間、および、噛合する櫛歯状電極５１，５５の間にそれぞれ静電引力が生じ、可動部２３に圧縮力が付与される。このため、湾曲した前記可動部２３の厚さ方向の付勢力の一部が減少し、前述と同様、低い駆動電圧で可動部２３を反転させることができる。他は前述の第１実施形態と同様であるので、説明を省略する。

【００２５】前述の実施形態では、接点の開閉は必ずしも常圧で行う必要はなく、減圧した密封空間内で接点を開閉してもよく、また、アルゴン，窒素，六フッ化硫黄等の気体を密封空間内に充填しておいてもよい。接点間のアークによる絶縁膜の発生、接点の溶着，劣化を防止できるからである。

【００２６】

【発明の効果】以上の説明から明らかなように、本発明の請求項１にかかるマイクロリレーによれば、湾曲する可動部の中央部に設けた可動接点が厚さ方向に大きく変位して一対の固定接点に接離し、これらを導通させる。このため、所望の接点圧を確保しつつ、所望の接点間距離を同時に確保でき、耐圧が高い。また、可動部自身は単結晶の薄板基材からなり、軽いので、慣性力が小さい。このため、疲労破壊が生じにくく、耐久性に優れている。さらに、可動接点が一対の固定接点に直接接触して導通させるので、半導体スイッチング素子と異なり、接点がオンするときの抵抗が小さく、周波数特性が高いとともに、入出力間や同極端子間の絶縁性が高い。そして、一方側に湾曲するように固定支持されている可動部は駆動手段を介して厚さ方向に変位可能である。このため、本願発明によれば、双方向に安定した自己保持型マイクロリレーが得られる。請求項２によれば、可動部の全周縁部を固定支持したダイヤフラム形状としてある。このため、可動部に捩れが生じにくく、接点の片当たりが生じない。請求項３によれば、電圧を印加して生じる静電引力で可動部を駆動するので、消費電力の少ない節電型マイクロリレーが得られる。請求項４によれば、可動部の表裏面に対して所定間隔で対向するように固定基板を設けてあるので、密封型で、かつ、少なくとも２組の固定接点を交互に開閉できるマイクロリレーが得られる。請求項５によれば、固定基板がガラス材あるいは単結晶シリコン材であり、マイクロマシニング技術を適用できるので、生産性の高いマイクロリレーが得られる。請求項６，７によれば、可動部の厚さ方向の付勢力を増大させる付勢手段を設けてあるので、所望の接点圧を確保しやすくなる。請求項８，９，１０によれば、補助駆動手段が湾曲した可動部の厚さ方向の付勢力を駆動時に減少させるので、可動部の反転動作が俊敏になり、駆動電圧を低減できる。請求項１１によれば、可動部が減圧された密封空間内に配置されているので、可動部の空気抵抗が減少し、動作特性が向上する。請求項１２によれば、密封空間内に絶縁膜発生防止気体を充填してあるので、接点間のアークに基づく絶縁不良が生じにくくなり、耐久性，信頼性が向上する。請求項１３によれば、衝撃吸収材が外部からの振動等を吸収，緩和するので、誤動作が生じにくいマイクロリレーが得られるという効果がある。

【図面の簡単な説明】

【図１】　本願発明の第１実施形態にかかるマイクロリレーを示す断面図である。

【図２】　図１に示したマイクロリレーの構成要素を示し、図（ａ）は上部固定基板の平面図、図（ｂ）は上部固定基板の底面図、図（ｃ）は可動基板の平面図、図（ｄ）は下部固定基板の平面図である。

【図３】　第２実施形態にかかるマイクロリレーの可動基板を示す平面図である。

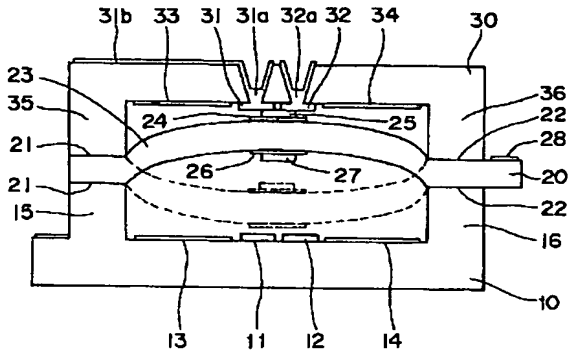
【図４】　第３実施形態にかかるマイクロリレーの可動基板を示す平面図である。

【符号の説明】

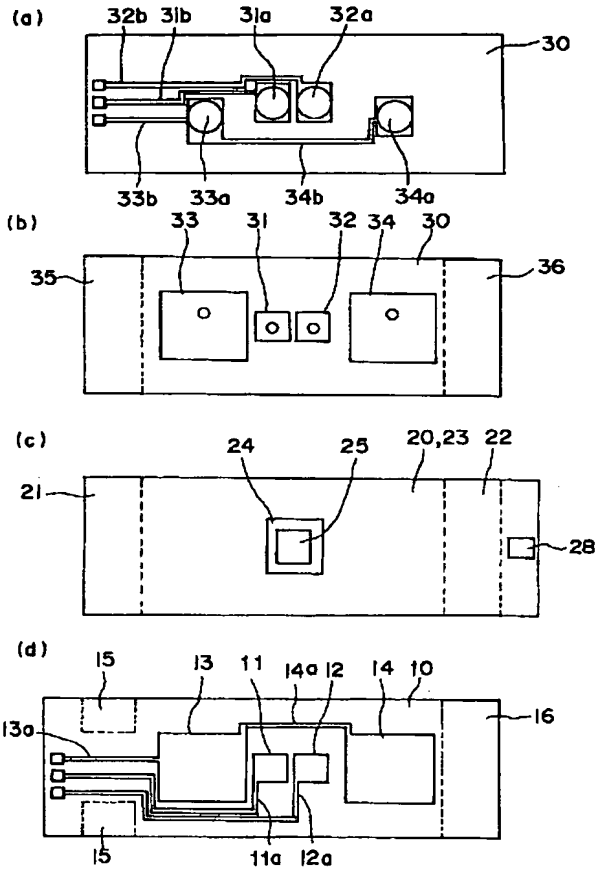
１０…下部固定基板、１１，１２…固定接点、１３，１４…駆動電極、２０…可動基板、２１，２２…接合領域、２３…可動部、２５，２７…可動接点、３０…上部固定基板、３１，３２…固定接点、３３，３４…駆動電極、３１ａ，３２ａ，３３ａ，３４ａ…スルーホール、４０，４１…圧電薄膜、５０，５１，５３，５５…櫛歯

状電極、５６…絶縁部。

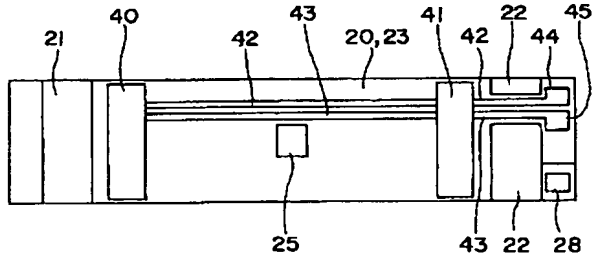
【図１】



【図２】



【図３】



【図４】